PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION, NO. 56: SOYBEAN RUST

Prepared by A. Green, Biological Assessment Support Staff, PPQ, APHIS, USDA, Federal Building Room 634, Hyattsville, MD 20782

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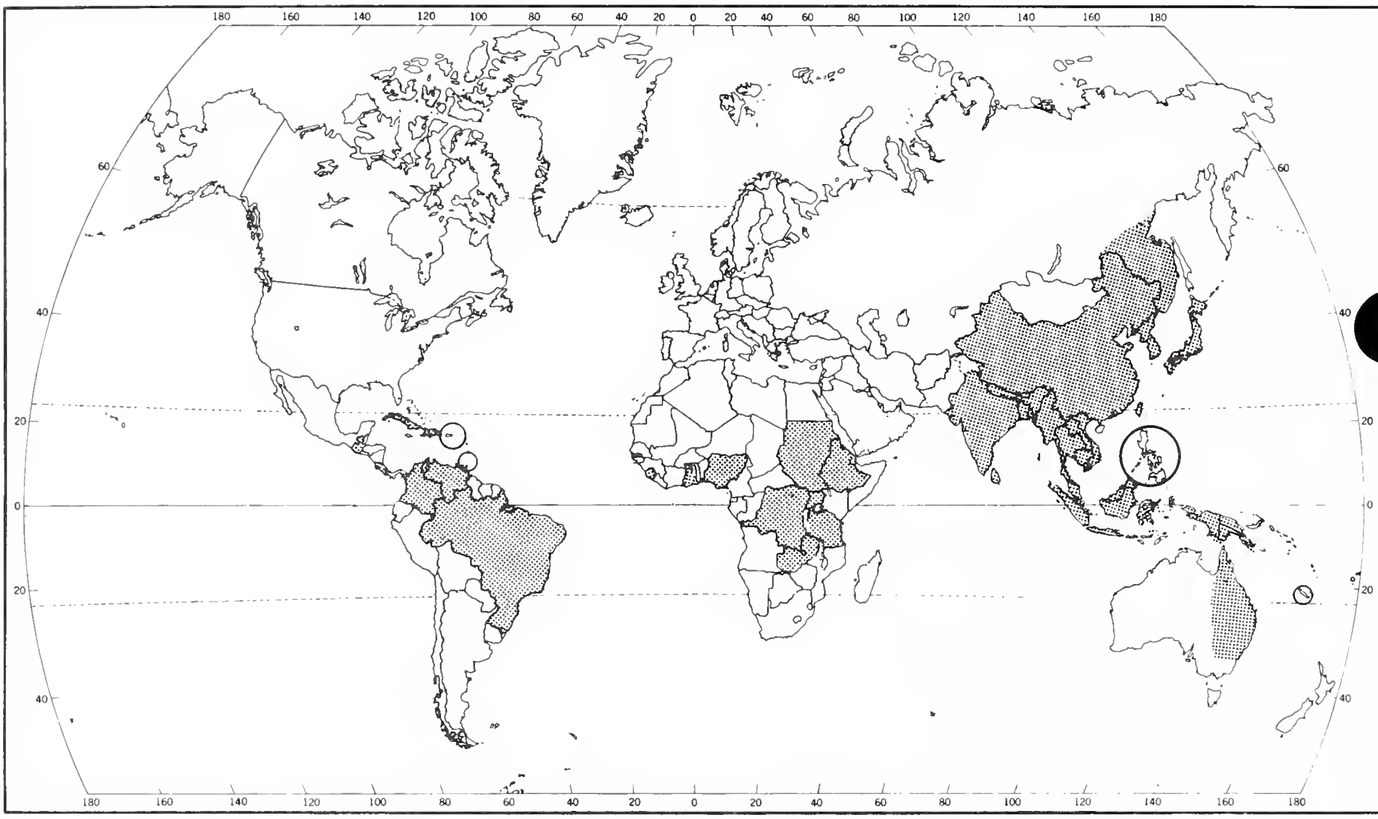
| Disease | SOYBEAN RUST |
| Pathogen | *Phakopsora pachyrhizi* Sydow |
| Selected Synonyms | *Phakopsora vignae* Arthur<br>*Uredo sojae* P. Hennings<br>*Phakopsora sojae* (P. Hennings) Sawada |
| Class: Order: Family | Basidiomycetes: Uredinales: Melampsoraceae |
| Economic Importance | Soybean rust is a major problem in soybean-growing regions of the Eastern Hemisphere. Losses in soybean yield during the 1971 rainy season in Thailand ranged from 10 to 30 percent. Reports from the southeastern areas of China indicate that losses of 10-30 percent are common and losses of over 50 percent occurred in years with severe rust (Bromfield 1980). |
| Hosts | The uredial stage of *Phakopsora pachyrhizi* has been reported on the following list of leguminous hosts. An asterisk indicates hosts for which telia and teliospores have also been reported. The list includes *Cajanus cajan* (pigeon pea), *Canavalia villosa**, *Centrosema pubescens*, *Crotalaria linifolia**, *Desmodium rhytidophyllum**, *Glycine max* (soybean)*, *G. soja* (wild soybean), *Lespedeza* spp. (bush clover), *Lotus* spp., *Lupinus* spp. (lupine), *Macroptilium* sp., *Mucuna capitata*, *Neonotonia wightii*, *Pachyrhizus erosus* (yam bean)*, *Phaseolus coccineus* (scarlet runner bean), *Phaseolus longepedunculatus*, *Phaseolus lunatus* (lima bean), *Phaseolus vulgaris* (garden bean), *Psoralea* spp. (scurfpea), *Pueraria lobata* (kudzu), *Pueraria phaseoloides* (tropical kudzu), *Teramnus uncinatus*, *Vigna mungo* (black gram), *V. radiata* (mung bean), *V. repens*, and *V. unguiculata* (cowpea, yard-long bean).<br><br>In 1961, the USDA soybean germplasm collection was field tested in Taiwan for resistance to soybean rust. Only two accessions, both of Japanese origin, exhibited appreciable resistance to rust. No commercial U.S. soybean cultivars are completely resistant (Bromfield 1980). |

General Distribution

Australia (Queensland and New South Wales), Bangladesh, Barbados, Brazil, Burma, China (including Taiwan), Colombia, Costa Rica, Cuba, Dominican Republic, Ethiopia, Ghana, Guatemala, India, Indonesia, Japan (including Ryukyu Islands), Kampuchea, Korea, Laos, Malaysia, Nepal, New Caledonia, Nigeria, Okinawa, Papua New Guinea, Philippines, Puerto Rico, Sao Tome, Sierra Leone, Soviet Union (Far East), Sri Lanka, Sudan, Tanzania, Thailand, Uganda, Venezuela, Vietnam, Virgin Islands, Zaire, and Zambia (Commonwealth Mycological Institute 1982).



Phakopsora pachyrhizi distribution map prepared by Non-Regional Administrative Operations Office and Biological Assessment Support Staff, PPQ, APHIS, USDA

Characters

Aecium and spermagonia - Not known to exist.

UREDIAL STAGE - Uredia erupt as small 'bumps' within a tan or brown lesion, most commonly on underside of soybean leaf, round or elliptical when viewed from above, 100-200 µm in diameter. Incurved paraphyses, basally united, form domelike covering for uredia. Ovate or oblong uredospores about 20 X 30 µm, hyaline to yellowish brown, produced inside uredia (Bromfield 1976, Yang 1977).

TELIAL STAGE - Individual telia hypophyllous, subepidermal, 150-250 µm in diameter, appearing as black dots arranged along margins of lesions or between lesions. Single celled teliospores arranged in 2-5 irregular layers throughout telium, about 18-19 µm long X 4-13 µm wide, smooth walled, and yellow to brownish (Bromfield 1976).

Basidia - No germination of teliospores has been reported.

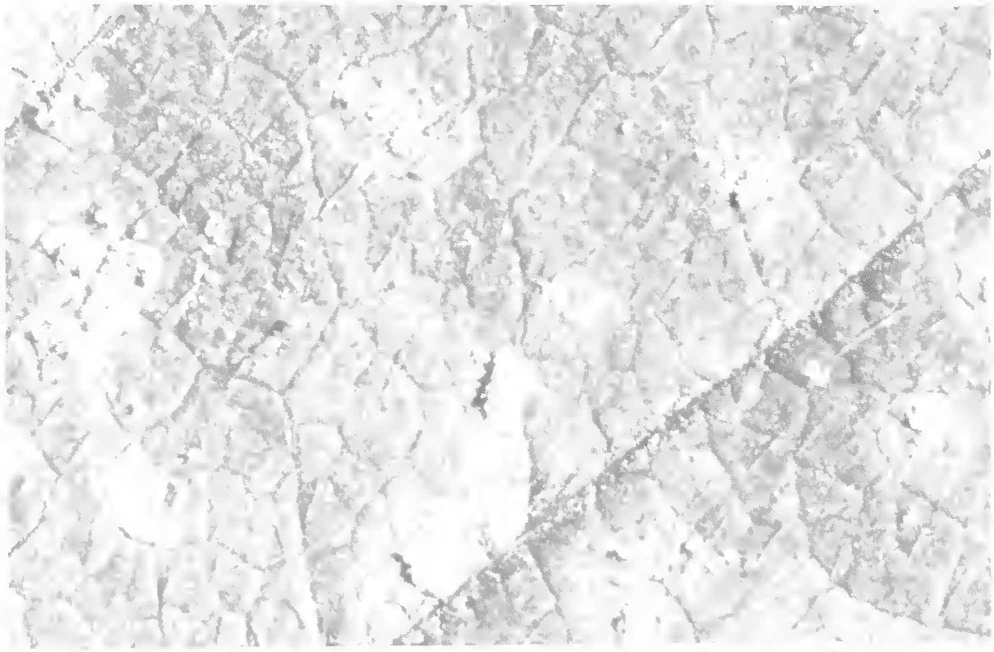
Characteristic Damage

The first disease symptoms appear as gray or brown spots on the leaf surface and less frequently on the stem and petiole. These spots later develop into either reddish brown (RB-type) or tan (TAN-type) lesions depending on the particular fungal isolate. The lesions are angular, delineated by the adjacent vascular bundles. As the disease progresses, the lesions grow larger and may coalesce (Yang 1977). TAN-type lesions (Fig. 1) are associated with more virulent strains of rust, producing more uredia and higher loss of yield than RB-type (Fig. 2).

Soybean rust can be confused with bacterial pustule (*Xanthomonas campestris* pv. *phaseoli* (Smith) Dye) which also causes a raised, light brown blister within a lesion on the underside of the soybean leaf. The bacterial leaf lesions vary from small specks to large irregular brown areas which form when small lesions coalesce. The raised blister-like pustules in the lesions resemble the uredial cones of the rust but can be distinguished by two microscopic characteristics. The uredial cones open through a round ostiole while the bacterial pustule is torn across by a fissure. Also, white clumps of uredospores can generally be observed lodged on top of the uredial cone. The fungal spores can be easily identified by microscopic examination.

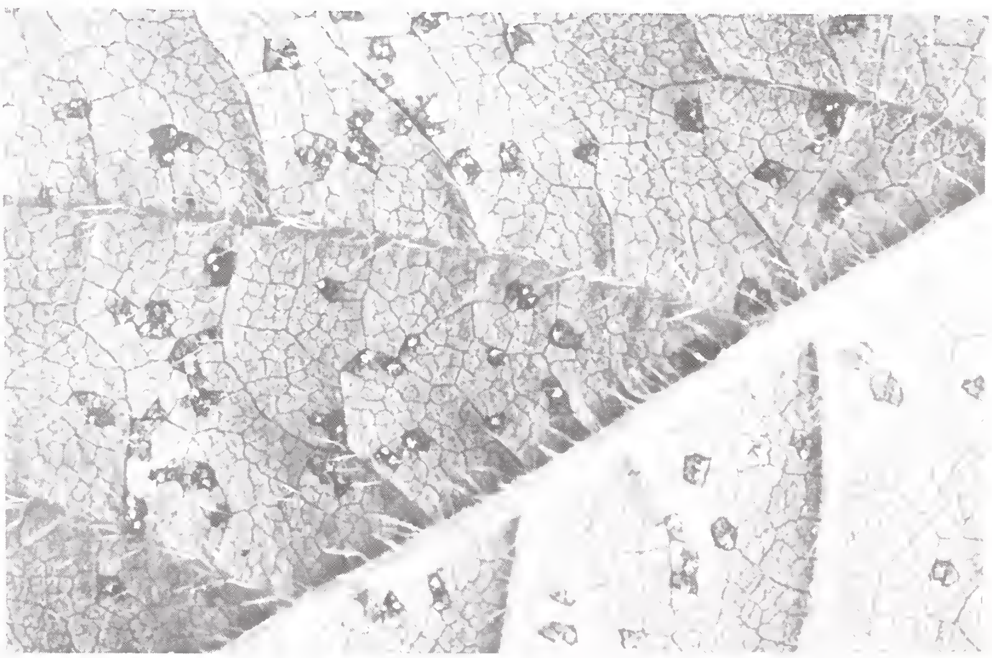
Bacterial pustules appear on the pods of susceptible hosts as small reddish brown, raised spots. Soybean rust does not attack the pods (Vakili and Bromfield 1976).

(Fig. 1)



*Phakopsora pachyrhizi* tan lesion (TAN-type) on soybean leaf (USDA photo).

(Fig. 2)



*Phakopsora pachyrhizi* reddish-brown lesion (RB-type) on soybean leaf (USDA photo).

Common bean rust (*Uromyces appendiculatus* (Pers.) Unger) is another disease of various *Phaseolus* spp. It produces brick-red lesions which should not be mistaken for the tan pustules caused by *Phakopsora pachyrhizi* (Vakili and Bromfield 1976).

Soybean rust generally appears on the lower leaves first and then progresses up the plant. Premature defoliation occurs on heavily infected plants. The rust reduces the number of normal pods and increases the number of unfilled pods per plant. There is a reduction in the weight of seeds per plant as well as the 1,000-seed weight (Bromfield 1976, Kitani and Inoue 1960, Ogle, Byth, and McLean 1979).

Different strains of the pathogen vary in aggressiveness and virulence as well as in host range. Rust strains reported in Puerto Rico have a low virulence toward commercial soybeans in contrast to the highly virulent Asian strains (Vakili and Bromfield 1976).

Soybean rust in Puerto Rico occurs primarily on the wild host, *Dolichos lablab* (hyacinth bean). Indigenous strains of the rust fungus were not highly virulent to 26 cultivars of soybeans tested in the field (Vakili and Bromfield 1976, Vakili 1976, personal communication). Rusted foliage on susceptible soybean hosts developed the red-brown type lesions with few uredia, suggesting some degree of resistance. The disease has a limited natural geographical range in Puerto Rico, occurring mainly in areas of high altitude and high rainfall.

The pathogen's low virulence and limited geographical range in Puerto Rico reduce the chances of epidemic on cultivated soybeans there. Vakili and Bromfield (1976) speculated that a more virulent strain of the soybean rust could evolve as soybean monoculture is expanded in Puerto Rico and in other regions of the Western Hemisphere where the pathogen is present on native hosts.

**Detection Notes**

1. Seeds of soybean rust hosts intended for planting and arriving in the United States from regions where the pathogen is present may carry rust spores as an external contaminant. These seeds must receive chemical treatment as a condition of entry as specified in Title 7, Part 319.37-6(e) of the Code of Federal Regulations.

2. Look for angular lesions primarily on leguminous leaves. There is no evidence of internal seedborne transmission. Uredial lesions are usually buff, tan, or brown, not the 'rust' color typical in diseases of that name.

3. Submit for identification, dried, pressed leaves showing symptoms. To prevent disease dissemination, specimens should be shipped in double containers (one container inside another) with screw tops.

## Biology and Etiology

The uredial stage of _P. pachyrhizi_ is the stage most frequently observed. Successive cycles of uredospore production during a single growing season cause epidemic conditions.

Uredospores of _P. pachyrhizi_ germinate between 10° C and 28.5° C with an optimal range of 15-25° C. For infection of soybean leaves, free water is necessary. The minimal 'dew period' necessary for infection is 6 hours at 20-25° C and 8-10 hours at 15-17.5° C (Marchetti, Melching, and Bromfield 1976).

Infection follows uredospore germination on host plant leaves. Appressoria (organs of attachment) begin developing within 8 hours of artifical inoculation. Leaf penetration is accomplished directly through the underlying cuticle of the epidermal cell. Intercellular hyphal growth follows in the palisade and spongy mesophyll. Haustoria (organs of absorption) form in mesophyll and epidermal cells, completing the infection process.

Uredial primordia appear within 7 days after inoculation. After 2 additional days the uredia mature, uredospores are differentiated, and spore release begins. The uredospores are forced through the pore of the uredia, and disseminated primarily by wind or water. New uredia continue to form for 4 weeks making the inoculum potential of the fungus appreciable (Koch, Ebrahim-Nesbat, and Hoppe 1983, Marchetti, Uecker, and Bromfield 1975, Pua and Ilag 1980).

On certain host plant genera, telial production has been observed (see Host Section). Senescence of foliage, cooler temperatures, and decreasing sunlight all favor increased telial production (Yeh, Sinclair, and Tschanz 1982). Germination of teliospores has not been reported, so their function is not understood.

Spermagonia and aecia have not been observed for the soybean rust fungus. Alternate hosts are not known (Bromfield 1976).

Under natural conditions of rainfall and temperature fluctuations, uredospores are short lived. Ilag (1977) was unable to germinate uredospores after 8 days of storage in either plant debris or soil, under dry or moist conditions in the laboratory. The short viability period for uredospores combined with the absence of functional teliospores makes wild hosts and volunteer soybeans important for pathogen survival. In Australia and Taiwan, soybean rust occurs on wild soybean species and on other pasture legumes. These hosts serve as sources of primary inoculum for the establishment of rust on commercial soybeans. In areas where no supplemental hosts exist, wind dissemination may provide the inoculum for primary infection (Bromfield 1976).

If soybean infection should begin early in the growing season, there is great potential for an epidemic with associated heavy yield losses. In Taiwan, six to eight uredial cycles can occur during a single soybean-growing season. The potential is good for similar disease development and epidemiology in North America. Some soybean-producing areas in the southern United States are climatologically analogous to parts of Japan and China where soybean rust is severe. Likewise, known wild host species exist in the United States (Bromfield 1980).

## Control

Use of resistant cultivars offers the best control for soybean rust. Although no soybean varieties are completely resistant to all races of rust, there are varying degrees of resistance in some soybean genotypes. Active breeding programs are currently being conducted in Asia and Australia. In the United States, there is a cooperative research program between the USDA and American soybean breeders to find and incorporate rust resistance into commercial cultivars for possible future use (Melching 1984, personal communication).

Certain cultural practices give a small degree of control. It is recommended to avoid the planting of soybeans in proximity to land containing wild weed hosts. Growing of early or late-maturing cultivars sometimes avoids peak rust periods.

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